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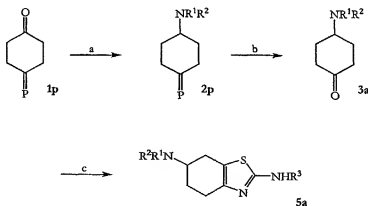
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(54) Title: PROCESS FOR THE PREPARATION OF 2-AMINO-4,5,6,7-TETRAHYDRO-6-AMINOBENZOTHAIOLES FROM CYCLOHEXANES AND CYCLOHEXANONES AS INTERMEDIATES



a: reductive amination with R^1R^2NH

b: deprotection

c: (i) iodine, $H_2N(C=S)NHR^3$; (ii) OH^-

(57) Abstract: The present invention relates to processes for the preparation of 2-amino-4,5,6,7-tetrahydro-6-aminobenzothiazoles (5a) from cyclohexanes (2a) and cyclohexanones (3a) as intermediate.



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PROCESS FOR THE PREPARATION OF 2-AMINO-4,5,6,7-TETRAHYDRO-6-AMINOBENZOTHAZOLES FROM CYCLOHEXANES AND CYCLOHEXANONES AS INTERMEDIATES

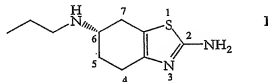
Technical field

5 The present invention relates to processes for the preparation of 2-amino-4,5,6,7-tetrahydro-6-aminobenzothiazoles and to novel cyclohexanes and cyclohexanones for use in these processes.

Background art

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Certain 2-amino-4,5,6,7-tetrahydro-6-aminobenzothiazoles are known to have dopamine D-2 activity and are therefore potentially useful as pharmaceuticals for the treatment of psychiatric disorders such as schizophrenia and Alzheimer's disease. One such compound, the dihydrochloride salt of (S)-2-amino-4,5,6,7-
15 tetrahydro-6-(propylamino)-benzothiazole I (pramipexole), is marketed as a pharmaceutical for the treatment of Parkinson's disease. The numbering of pramipexole I is indicated below.



20 Processes for the preparation of 2-amino-4,5,6,7-tetrahydro-6-aminobenzothiazoles are disclosed in patents US 4843086, US 4886812 and patent applications WO 02/22590 A1 and WO 02/22591 A1. A procedure to these types of compound is also disclosed by C.S. Schneider and J. Mierau in J. Med. Chem., 1987, vol. 30, pages 494-498.

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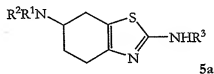
However, known processes for the preparation of 2-amino-4,5,6,7-tetrahydro-6-aminobenzothiazoles are not satisfactory, particularly for industrial scale manufacture, as they have been found to be low yielding and involve the use of

hazardous and difficult to handle reagents such as bromine, hydrazine and potassium chromate.

Summary of the invention

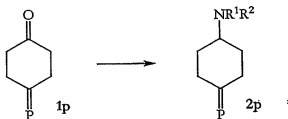
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A first aspect of the present invention is a process for the preparation of a 2-amino-4,5,6,7-tetrahydro-6-aminobenzothiazole 5a



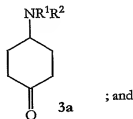
or a salt thereof, comprising the steps of:

- 10 (a) reductively aminating a protected cyclohexandione 1p with an amine R^1R^2NH to yield a protected 4-amino-cyclohexanone 2p:



wherein P is a protected ketone functionality, and R^1 and R^2 are any atom or group or, together with the nitrogen to which they are attached, form a ring;

- 15 (b) deprotecting the protected 4-amino-cyclohexanone 2p to yield an unprotected 4-amino-cyclohexanone 3a



- (c) treating the unprotected 4-amino-cyclohexanone 3a with iodine and a substituted thiourea $H_2N(C=S)NHR^3$, wherein R^3 is any atom or group, to yield the 2-amino-4,5,6,7-tetrahydro-6-aminobenzothiazole 5a or a salt thereof.
- 20

For the purposes of the present invention, an "alkyl" group is defined as a monovalent saturated hydrocarbon, which may be straight-chained or branched, or be or include cyclic groups. Examples of alkyl groups are methyl, ethyl, *n*-propyl, *i*-propyl, *n*-butyl, *i*-butyl, *t*-butyl and *n*-pentyl groups. Preferably an alkyl group is straight-chained or branched and does not include any heteroatoms in its carbon skeleton. Preferably an alkyl group is a C_1 - C_{12} alkyl group, which is defined as an alkyl group containing from 1 to 12 carbon atoms. More preferably an alkyl group is a C_1 - C_6 alkyl group, which is defined as an alkyl group containing from 1 to 6 carbon atoms. An "alkylene" group is similarly defined as a divalent alkyl group.

An "alkenyl" group is defined as a monovalent hydrocarbon, which comprises at least one carbon-carbon double bond, which may be straight-chained or branched, or be or include cyclic groups. Examples of alkenyl groups are vinyl, allyl, but-1-enyl and but-2-enyl groups. Preferably an alkenyl group is straight-chained or branched and does not include any heteroatoms in its carbon skeleton. Preferably an alkenyl group is a C_2 - C_{12} alkenyl group, which is defined as an alkenyl group containing from 2 to 12 carbon atoms. More preferably an alkenyl group is a C_2 - C_6 alkenyl group, which is defined as an alkenyl group containing from 2 to 6 carbon atoms. An "alkenylene" group is similarly defined as a divalent alkenyl group.

An "alkynyl" group is defined as a monovalent hydrocarbon, which comprises at least one carbon-carbon triple bond, which may be straight-chained or branched, or be or include cyclic groups. Examples of alkynyl groups are ethynyl, propargyl, but-1-ynyl and but-2-ynyl groups. Preferably an alkynyl group is straight-chained or branched and does not include any heteroatoms in its carbon skeleton. Preferably an alkynyl group is a C_2 - C_{12} alkynyl group, which is defined as an alkynyl group containing from 2 to 12 carbon atoms. More preferably an alkynyl group is a C_2 - C_6 alkynyl group, which is defined as an alkynyl group containing from 2 to 6 carbon atoms. An "alkynylene" group is similarly defined as a divalent alkynyl group.

An "aryl" group is defined as a monovalent aromatic hydrocarbon. Examples of aryl groups are phenyl, naphthyl, anthracenyl and phenanthrenyl groups. Preferably

an aryl group does not include any heteroatoms in its carbon skeleton. Preferably an aryl group is a C_6 - C_{14} aryl group, which is defined as an aryl group containing from 4 to 14 carbon atoms. More preferably an aryl group is a C_6 - C_{10} aryl group, which is defined as an aryl group containing from 6 to 10 carbon atoms. An
 5 "arylene" group is similarly defined as a divalent aryl group.

Where a combination of groups is referred to as one moiety, for example, arylalkyl, arylalkenyl, arylalkynyl, alkylaryl, alkenylaryl or alkynylaryl, the last mentioned group contains the atom by which the moiety is attached to the rest of the molecule. A
 10 typical example of an arylalkyl group is benzyl.

For the purposes of this invention, an optionally substituted alkyl, alkenyl, alkynyl, aryl, arylalkyl, arylalkenyl, arylalkynyl, alkylaryl, alkenylaryl or alkynylaryl group may be substituted with one or more of -F, -Cl, -Br, -I, -CF₃, -CCl₃, -CBr₃, -Cl₂, -OH,
 15 -SH, -NH₂, -CN, -NO₂, -COOH, -R⁴-O-R⁵, -R⁴-S-R⁵, -R⁴-SO-R⁵, -R⁴-SO₂-R⁵, -R⁴-SO₂-OR⁵, -R⁴O-SO₂-R⁵, -R⁴-SO₂-N(R⁵)₂, -R⁴-NR⁵-SO₂-R⁵, -R⁴O-SO₂-OR⁵, -R⁴O-SO₂-N(R⁵)₂, -R⁴-NR⁵-SO₂-OR⁵, -R⁴-NR⁵-SO₂-N(R⁵)₂, -R⁴-N(R⁵)₂, -R⁴-N(R⁵)₃⁺, -R⁴-P(R⁵)₂, -R⁴-Si(R⁵)₃, -R⁴-CO-R⁵, -R⁴-CO-OR⁵, -R⁴O-CO-R⁵, -R⁴-CO-N(R⁵)₂, -R⁴-NR⁵-CO-R⁵, -R⁴O-CO-OR⁵, -R⁴O-CO-N(R⁵)₂, -R⁴-NR⁵-CO-OR⁵,
 20 -R⁴-NR⁵-CO-N(R⁵)₂, -R⁴-CS-R⁵, -R⁴-CS-OR⁵, -R⁴O-CS-R⁵, -R⁴-CS-N(R⁵)₂, -R⁴-NR⁵-CS-R⁵, -R⁴O-CS-OR⁵, -R⁴O-CS-N(R⁵)₂, -R⁴-NR⁵-CS-OR⁵, -R⁴-NR⁵-CS-N(R⁵)₂ or -R⁵. In this context, -R⁴- is independently a chemical bond, a C_1 - C_{10} alkylene, C_1 - C_{10} alkenylene or C_1 - C_{10} alkynylene group. -R⁵ is independently hydrogen, unsubstituted C_1 - C_6 alkyl or unsubstituted C_6 - C_{10} aryl. Optional
 25 substituent(s) are not taken into account when calculating the total number of carbon atoms in the parent group substituted with the optional substituent(s).

Any optional substituent may be protected. Suitable protecting groups for protecting optional substituents are known in the art, for example from "Protective
 30 Groups in Organic Synthesis" by T.W. Greene and P.G.M. Wuts (Wiley-Interscience, 2nd edition, 1991).

For the purposes of this invention, a "salt" is any acid addition salt, preferably a pharmaceutically acceptable acid addition salt, including but not limited to a hydrohalogenic acid salt such as hydrofluoric, hydrochloric, hydrobromic and hydroiodic acid salt; an inorganic acid salt such as nitric, perchloric, sulfuric and phosphoric acid salt; an organic acid salt such as a sulfonic acid salt (for example methanesulfonic, trifluoromethanesulfonic, ethanesulfonic, isethionic, benzenesulfonic, p-toluenesulfonic or camphorsulfonic acid salt), acetic, malic, fumaric, succinic, citric, tartaric, benzoic, gluconic, lactic, mandelic, mucic, pantoic, pantothenic, oxalic and maleic acid salt; and an amino acid salt such as ornithinic, glutamic and aspartic acid salt. The acid addition salt may be a mono- or di-acid addition salt. A preferred salt is a di-hydrohalogenic, di-sulphuric, di-phosphoric or di-organic acid salt. A most preferred salt is a di-hydrochloric acid salt.

P is a protected ketone functionality. Suitable protecting groups are commonly known in the art, for example from Chapter 4 of "Protective Groups in Organic Synthesis" by T.W. Greene and P.G.M. Wuts (Wiley-Interscience, 2nd edition, 1991).

Preferably the protected ketone functionality P is an acyclic ketal or derivative **1q**, a cyclic ketal or derivative **1r**, **1s** or **1t**, or a hydrazone or oxime **1u**, as shown in Figure 4. More preferably P is a cyclic ketal **1r**, most preferably P is a monoethyleneketal **1**, as shown in Figures 2 and 3.

R¹, R² and R³ can be any atom or group. Preferably R¹ and R² are not amine protecting groups. Amine protecting groups are commonly known in the art, for example from Chapter 7 of "Protective Groups in Organic Synthesis" by T.W. Greene and P.G.M. Wuts (Wiley-Interscience, 2nd edition, 1991). Most preferably one of R¹ and R² is hydrogen and the other of R¹ and R² is an optionally substituted alkyl, alkenyl, alkynyl, aryl, arylalkyl, arylalkenyl, arylalkynyl, alkylaryl, alkenylaryl or alkynylaryl group, which may include one or more heteroatoms N, O or S in its carbon skeleton. Such an optionally substituted alkyl, alkenyl, alkynyl, aryl, arylalkyl, arylalkenyl, arylalkynyl, alkylaryl, alkenylaryl or alkynylaryl group, which may include one or more heteroatoms N, O or S in its carbon skeleton, does not encompass carbonyl -CO-R groups, wherein R is any atom or group.

Optionally R^1 , R^2 and R^3 are independently hydrogen or an optionally substituted alkyl, alkenyl, alkynyl, aryl, arylalkyl, arylalkenyl, arylalkynyl, alkylaryl, alkenylaryl or alkynylaryl group, which may include one or more heteroatoms N, O or S in its carbon skeleton.

Optionally R^1 , R^2 and R^3 are independently an alkyl, alkenyl, alkynyl, aryl, arylalkyl, arylalkenyl, arylalkynyl, alkylaryl, alkenylaryl or alkynylaryl group, which may include one or more heteroatoms N, O or S in its carbon skeleton, and which may be optionally substituted with one or more of -F, -Cl, -Br, -I, -CF₃, -CCl₃, -CBr₃, -Cl₃, -OH, -SH, -NH₂, -CN, -NO₂, -COOH, -R⁴-O-R⁵, -R⁴-S-R⁵, -R⁴-SO-R⁵, -R⁴-SO₂-R⁵, -R⁴-N(R⁵)₂, -R⁴-Si(R⁵)₃, -R⁴-CO-R⁵, -R⁴-CO-OR⁵, -R⁴-CO-N(R⁵)₂, -R⁴-NR⁵-CO-R⁵, -R⁴-CS-R⁵ or -R⁵, wherein

-R⁴- is independently a chemical bond, a C₁-C₁₀ alkylene, C₁-C₁₀ alkenylene or C₁-C₁₀ alkynylene group, and

-R⁵ is independently hydrogen, unsubstituted C₁-C₆ alkyl or unsubstituted C₆-C₁₀ aryl.

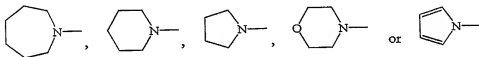
Optionally R^1 , R^2 and R^3 are independently an alkyl, alkenyl, alkynyl, aryl, arylalkyl, arylalkenyl, arylalkynyl, alkylaryl, alkenylaryl or alkynylaryl group, which does not include any heteroatoms in its carbon skeleton, and which may be optionally substituted with one or more of -F, -Cl, -Br, -I, -CF₃, -CCl₃, -CBr₃, -Cl₃, -OH, -SH, -NH₂, -CN, -NO₂, -COOH, -OR⁵, -SR⁵, -SO-R⁵, -SO₂-R⁵, -N(R⁵)₂, -Si(R⁵)₃, -CO-R⁵, -CO-OR⁵, -O-CO-R⁵, -CO-N(R⁵)₂, -NR⁵-CO-R⁵, -CS-R⁵ or -R⁵, wherein

-R⁵ is independently hydrogen, unsubstituted C₁-C₆ alkyl or unsubstituted C₆-C₁₀ aryl.

Preferably R^1 , R^2 and R^3 are independently hydrogen or an unsubstituted alkyl, aryl or heteroaryl group, which does not include any heteroatoms N, O or S in its carbon skeleton. More preferably, R^1 , R^2 and R^3 are independently hydrogen or an unsubstituted C₁₋₁₀ alkyl group. More preferably, R^1 , R^2 and R^3 are independently hydrogen or an unsubstituted C₁₋₆ alkyl group. More preferably, one of R^1 and R^2 is hydrogen and the other of R^1 and R^2 is an unsubstituted C₁₋₆ alkyl group, and R^3 is

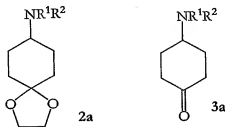
hydrogen. Most preferably, one of R^1 and R^2 is hydrogen and the other of R^1 and R^2 is *n*-propyl, and R^3 is hydrogen.

- Alternatively, R^1 and R^2 can, together with the nitrogen to which they are attached, form a ring. Optionally $-NR^1R^2$ together form an optionally substituted heterocycloalkyl, heterocycloalkenyl or heteroaryl ring. Optionally $-NR^1R^2$ together form



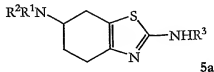
- 10 Preferably the reductive amination of step (a) is carried out with $NaCNBH_3$.

A second aspect of the present invention is a 4-amino-cyclohexanone-ethyleneketal 2a or a 4-amino-cyclohexanone 3a



- 15 for use in a process of the first aspect of the present invention. R^1 and R^2 are as defined above with reference to the first aspect of the present invention. Preferably one of R^1 and R^2 is hydrogen and the other of R^1 and R^2 is *n*-propyl.

- A third aspect of the present invention is a 2-amino-4,5,6,7-tetrahydro-6-aminobenzothiazole 5a



or a salt thereof, obtained by a process of the first aspect of the present invention. R^1 , R^2 and R^3 are as defined above with reference to the first aspect of the present

invention. Preferably one of R^1 and R^2 is hydrogen and the other of R^1 and R^2 is *n*-propyl, and R^3 is hydrogen. Preferably the compound is a di-hydrochloric acid salt.

5 The 2-amino-4,5,6,7-tetrahydro-6-aminobenzothiazoles 5a or salts thereof have at least one chiral centre and can therefore exist in the form of various stereoisomers. The present invention embraces all of these stereoisomers and mixtures thereof. Mixtures of these stereoisomers can be resolved by conventional methods, for example, chiral chromatography, fractional recrystallisation, derivatisation to form diastereomers and subsequent resolution, and resolution using enzymes.

10

The 2-amino-4,5,6,7-tetrahydro-6-aminobenzothiazole 5a or salt thereof of the present invention preferably comprises at least 95% of the (R)- or the (S)-enantiomer, preferably at least 98% of the (R)- or the (S)-enantiomer, and more preferably at least 99% of the (R)- or the (S)-enantiomer. Generally, the (S)-
15 enantiomer is the preferred enantiomer.

20

The 2-amino-4,5,6,7-tetrahydro-6-aminobenzothiazole 5a or salt thereof may be used as a medicament, preferably for the treatment of a psychiatric or neurological disorder such as schizophrenia, Alzheimer's disease or Parkinson's disease.

A fourth aspect of the present invention is a pharmaceutical composition, comprising 2-amino-4,5,6,7-tetrahydro-6-aminobenzothiazole 5a or salt thereof and a pharmaceutically acceptable carrier or diluent. Preferably the pharmaceutical composition is suitable for the treatment of a psychiatric or neurological disorder
25 such as schizophrenia, Alzheimer's disease or Parkinson's disease.

30

A fifth aspect of the present invention is a method of treating a psychiatric or neurological disorder such as schizophrenia, Alzheimer's disease or Parkinson's disease, comprising administering a therapeutically effective amount of a 2-amino-4,5,6,7-tetrahydro-6-aminobenzothiazole 5a or a salt thereof to a subject in need of such treatment.

Brief description of the drawings

Figure 1 is a schematic illustration of the process of the present invention.

Figures 2 and 3 are schematic illustrations of preferred processes of the present invention.

Figure 4 illustrates preferred protected ketone functionalities P.

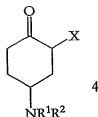
Detailed description of the invention

10 The inventors have found that processes for the preparation of 2-amino-4,5,6,7-tetrahydro-6-aminobenzothiazoles 5a are greatly improved by the process outlined in Figure 1, wherein R¹ and R² can be any atom or group or, together with the nitrogen to which they are attached, form a ring, and wherein R³ can be any atom or group. R¹, R² and R³ are preferably hydrogen or an unsubstituted alkyl, aryl or
15 heteroaryl group.

The process outlined in Figure 1 is short, utilises a readily available starting material, a protected cyclohexandione 1p, and does not require any hazardous chemical reagents. Each step of the process is high yielding and affords products of very
20 high purity.

Therefore a first aspect of the current invention is a process for the preparation of 2-amino-4,5,6,7-tetrahydro-6-aminobenzothiazoles 5a by the process specified in Figure 1.

25 It has been disclosed in prior art documents WO 02/22590 and WO 02/22591 that, in practice, compounds of formula 5a, comprising a primary amino or a secondary alkylamino group, cannot be prepared directly from the corresponding ketones 3a. The process shown in Figure 1, however, illustrates that the process of the current
30 invention does indeed allow a compound 5a to be prepared from ketones 3a directly without the requirement of preparing and isolating an α -haloketone of formula 4, where X is a halide such as chloride or bromide, or the requirement of a protecting group on the nitrogen atom of the amine substituent -NR¹R² of the ketone 3a.



Therefore, in a preferred embodiment of the present invention, the α -haloketone of formula 4 is not isolated. Moreover, in a preferred embodiment of the present invention, the nitrogen atom of the amine substituent $-NR^1R^2$ of the ketone 3a is not protected.

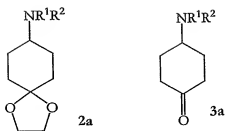
In a preferred embodiment of the first aspect of the invention, cyclohexandione is protected as a cyclohexandione monoethyleneketal 1, as shown in Figures 2 and 3.

A further preferred embodiment of the first aspect of the invention is a process for the preparation of 2-amino-4,5,6,7-tetrahydro-6-(propylamino)-benzothiazole 5, as outlined in Figure 3.

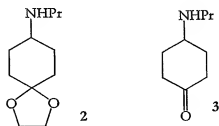
The process outlined in Figure 3 can readily be adapted to afford pramipexole I or its salts, for example by resolution of compound 5. Methods for resolving enantiomers are well known in the art and include, for example, chiral chromatography, fractional recrystallisation, derivatisation to form diastereomers and subsequent resolution, and resolution using enzymes.

A further aspect of the invention is therefore pramipexole I and its salts, when prepared by a process according to the current invention.

Further aspects of the invention include novel compounds of the formula 2a or 3a, wherein R^1 and R^2 are as defined above, which are useful intermediates in the synthesis of 2-amino-4,5,6,7-tetrahydro-6-aminobenzothiazoles 5a.



Preferred embodiments of these aspects are compounds 2 and 3, as shown in Figure 3.



5

The process outlined in Figure 3 is an example of a procedure comprising the process of the current invention and detailed procedures for this process are found in the experimental section. Compounds of the current invention are also exemplified in Figure 3 and in the experimental section.

10

The process of the present invention is short, utilises readily available starting materials and does not involve the use of hazardous or difficult to handle reagents such as bromine, hydrazine or potassium chromate. Each step of the process of the present invention is high yielding and affords products of very high purity. Thus the process is easy to scale up for industrial scale manufacturing. Optionally 2-amino-4,5,6,7-tetrahydro-6-aminobenzothiazoles 5a and salts thereof may be manufactured in batches of 5kg or more, or even 10kg or more.

15

20 Experimental procedure

4-n-Propylamino-cyclohexanone-ethyleneketal 2

A mixture of *n*-propyl amine (162ml, 1.474mol) in methanol (500ml) was chilled to 0-5°C. To this solution was added methanolic hydrochloric acid (155ml, 44.47%) dropwise over a period of 30 minutes to achieve a pH of 6-7. Cyclohexanone monoethyleneketal 1 (100g, 0.641mol) was charged at 5°C and the reaction was stirred for 15 minutes. Sodium cyanoborohydride (60g, 0.952mol) was added in 15 minutes at 5°C. The pH increased to about 8 and methanolic hydrochloric acid (15ml, 44.47%) was added to bring the pH to 6-7. The reaction was allowed to come to 24-26°C. Stirring was continued for 2 hours. Methanol was distilled off (450ml). Sodium carbonate (95g, 0.896mol) was dissolved in water (850ml) and charged to the reaction mass at ambient temperature in one shot. The reaction mass was extracted with dichloromethane (2500ml). The dichloromethane layers were combined and dried over sodium sulfate (8.5g). The dichloromethane layer was concentrated to dryness at 40°C and 15mbar pressure. The product 2 was light yellow viscous oil. The weight of the product 2 obtained was 135g (105.8%); GC purity 97.74%.

¹H NMR (δ ppm): 0.9-1.0 (t, 3H, CH₃ of *n*Pr); 1.5-1.7 (m, 7H, CH₂CH₃ of *n*Pr and 5H of cyclohexyl ring); 1.75-1.85 (m, 2H, 2H of cyclohexyl ring); 1.95-2.05 (m, 1H, 1H of cyclohexyl ring); 2.75 (t, 2H, CH₂CH₂CH₃ of *n*Pr); 3.75-3.85 (m, 1H, NHCH); 3.9 (s, 2H, CH₂ of ethylene ketal) and 4.0 (s, 2H, CH₂ of ethylene ketal).
¹³C NMR (δ ppm): 11.7 (CH₃ of *n*Pr); 21.8 (CH₂CH₃ of *n*Pr); 28.5 (C-3 and C-5); 33.1 (C-2 and C-6); 48.3 (CH₂CH₂CH₃ of *n*Pr); 55.8 (C-4); 64.5 (C of ethylene ketal); 64.6 (C of ethylene ketal); 108.1 (C-1).

4-*n*-Propylamino-cyclohexanone 3

4-*N*-propylamino-cyclohexanone-ethyleneketal 2 (134g, 0.673mol) was taken in tetrahydrofuran (268ml) and cooled to 4-6°C. Concentrated hydrochloric acid (178ml, 2.01mol) was diluted with water (2144ml) and the mixture was cooled to 4°C. This diluted hydrochloric acid was added to the reaction mixture at 4-6°C in 15 minutes. The reaction was allowed to come to 24-26°C and stirring was continued for 24 hours. The reaction mass (2750ml) was concentrated to 1800ml at 50°C and 35mbar pressure. Sodium carbonate (148g, 1.4mol) was added to achieve

pH 10. The reaction mixture was extracted with dichloromethane (3670ml). The dichloromethane layers were combined and dried over sodium sulfate (20g). The dichloromethane layer was concentrated to dryness at 40°C and 15mbar pressure. The product 3 was yellow viscous oil. The weight of the product 3 obtained was 52.5g (52.84%); GC purity 86.07%.

¹H NMR (δ ppm): 0.9-1.0 (t, 3H, CH₃ of *n*Pr); (m, 2H, CH₂CH₃ of *n*Pr); 1.6-1.75 (m, 2H, 2H of cyclohexyl ring); 2.05-2.15 (m, 2H, 2H of cyclohexyl ring); 2.2-2.3 (m, 2H, 2H of cyclohexyl ring); 2.4-2.55 (m, 2H, 2H of cyclohexyl ring); 2.55-2.65 (t, 2H, CH₂CH₂CH₃ of *n*Pr); 2.9-3.0 (m, 1H, NHCH).
¹³C NMR (δ ppm): 12.3 (CH₃ of *n*Pr); 24.0 (CH₂CH₃ of *n*Pr); 32.6 (C-3 and C-5); 39.1 (C-2 and C-6); 50.0 (CH₂CH₂CH₃ of *n*Pr); 54.4 (C-4); 211.9 (C-1).

2-Amino-6-*n*-propylamino-5,6,7,8-tetrahydrobenzthiazole 5

4-*n*-Propylamino-cyclohexanone 3 (5g, 32.26mmol) was charged in absolute ethanol (50ml) at 24-26°C. Iodine (8.5g, 33.5mmol) was added to it under stirring followed by thiourea (5g, 65.7mmol) at 24-26°C. The reaction mass was refluxed for 32 hours. Heating was stopped and the reaction mass was allowed to cool to 24-26°C. It was maintained at that temperature for 20 hours. 2-Amino-6-*n*-propylamino-5,6,7,8-tetrahydrobenzthiazole dihydroiodide salt crystallized out of the solution. Ethanol (30ml) was distilled out on the rotavapor at 50°C and 100mbar. Acetone (50ml) was added and the solid was filtered. The solid was dried at 40°C and 15mbar. The weight of the product obtained was 8.5g (56%); HPLC purity 94.97%.

¹H NMR (δ ppm): 0.9-1.0 (t, 3H, CH₃ of *n*Pr) 1.6-1.8 (m, 2H, CH₂CH₃ of *n*Pr); 2.0 (m, 1H, H-7a); 2.35 (m, 1H, H-7b); 2.7 (m, 3H, H-5a, H-8a, H-8b); 3.1 (m, 3H, H-5b and CH₂CH₂CH₃ of *n*Pr); 3.7 (m, 1H, NHCH).
¹³C NMR (δ ppm): 12.0 (CH₃ of *n*Pr); 21.0 (CH₂CH₃ of *n*Pr); 22.2 (C-7); 25.5 and 26.8 (C-5 and C-8); 48.7 (CH₂CH₂CH₃ of *n*Pr); 54.7 (C-6); 113.0 (C-4); 134 (C-9); 171.2 (C-2).

Mass Spec: M⁺ 211 (expected 211).

The 2-amino-6-*n*-propylamino-5,6,7,8-tetrahydrobenzthiazole dihydroiodide salt formed above (50g, 107.1mmol) was dissolved in water (200ml). The solution was cooled to 4°C and solid sodium hydroxide (50g, 1.25mol) was added in 15 minutes. The reaction was stirred for 1 hour at 24-26°C and the solid that precipitated out
5 was filtered and dried at 40°C and 15mbar. The weight of the product 5 obtained was 17.07g (75.5%); HPLC purity 99.88%.

¹H NMR (δ ppm): 0.9-1.0 (t, 3H, CH₃ of *n*Pr); 1.5-1.6 (m, 2H, CH₂CH₃ of *n*Pr); 2.1 (m, 1H, H-7a); 2.3 (m, 1H, H-7b); 2.5-2.6 (m, 5H, H-5a, H-5b, H-8a, H-8b and
10 CHCH₂CH₃ of *n*Pr); 2.9 (m, 2H, H-6 and CHCH₂CH₃ of *n*Pr).
¹³C NMR (δ ppm): 12.0 (CH₃ of *n*Pr); 24.6 (CH₂CH₃ of *n*Pr); 26.6 (C-7); 30.7 and 30.9 (C-5 and C-8); 50.7 (CH₂CH₂CH₃ of *n*Pr); 56.2 (C-6); 116.0 (C-4); 145 (C-9); 170.4 (C-2).

Mass Spec: M⁺ 211 (expected 211).

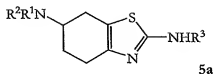
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It will be understood that the present invention has been described above by way of example only. The examples are not intended to limit the scope of the invention. Various modifications and embodiments can be made without departing from the scope of the invention, which is defined by the following claims.

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Claims

1. A process for the preparation of a 2-amino-4,5,6,7-tetrahydro-6-aminobenzothiazole 5a



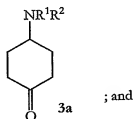
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or a salt thereof, comprising the steps of:

- (a) reductively aminating a protected cyclohexandione 1p with an amine R^1R^2NH to yield a protected 4-amino-cyclohexanone 2p:



- 10 wherein P is a protected ketone functionality, and R^1 and R^2 are any atom or group or, together with the nitrogen to which they are attached, form a ring;
- (b) deprotecting the protected 4-amino-cyclohexanone 2p to yield an unprotected 4-amino-cyclohexanone 3a

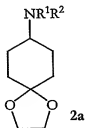


- 15 (c) treating the unprotected 4-amino-cyclohexanone 3a with iodine and a substituted thiourea $H_2N(C=S)NHR^3$, wherein R^3 is any atom or group, to yield the 2-amino-4,5,6,7-tetrahydro-6-aminobenzothiazole 5a or a salt thereof.

2. A process as claimed in claim 1, wherein P is a cyclic ketal 1r.

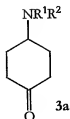
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3. A process as claimed in claim 2, wherein P is a monoethyleneketal 1.
4. A process as claimed in any preceding claim, wherein R¹, R² and R³ are independently hydrogen or an optionally substituted alkyl, alkenyl, alkynyl, aryl, arylalkyl, arylalkenyl, arylalkynyl, alkylaryl, alkenylaryl or alkynylaryl group, which may include one or more heteroatoms N, O or S in its carbon skeleton.
5. A process as claimed in any preceding claim, wherein R¹, R² and R³ are independently hydrogen or an unsubstituted alkyl, aryl or heteroaryl group, which does not include any heteroatoms N, O or S in its carbon skeleton.
6. A process as claimed in any preceding claim, wherein one of R¹ and R² is hydrogen and the other of R¹ and R² is an optionally substituted alkyl, alkenyl, alkynyl, aryl, arylalkyl, arylalkenyl, arylalkynyl, alkylaryl, alkenylaryl or alkynylaryl group, which may include one or more heteroatoms N, O or S in its carbon skeleton.
7. A process as claimed in claim 6, wherein one of R¹ and R² is hydrogen and the other of R¹ and R² is *n*-propyl.
8. A process as claimed in any preceding claim, wherein R³ is hydrogen.
9. A process as claimed in any preceding claim, wherein the reductive amination of step (a) is carried out with NaCNBH₃.
10. A 4-amino-cyclohexanone-ethyleneketal 2a



for use in a process as claimed in any one of claims 1 to 9.

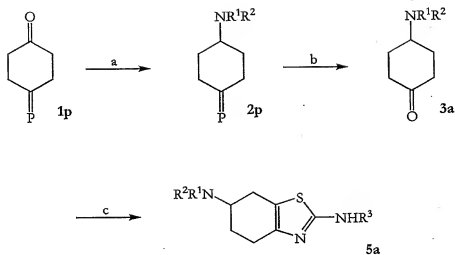
11. A 4-amino-cyclohexanone **3a**



for use in a process as claimed in any one of claims 1 to 9.

12. A compound as claimed in claim 10 or claim 11, wherein one of R¹ and R² is hydrogen and the other of R¹ and R² is *n*-propyl.
13. A 2-amino-4,5,6,7-tetrahydro-6-aminobenzothiazole **5a** or a salt thereof, obtained by a process as claimed in any one of claims 1 to 9.
14. A compound as claimed in claim 13, wherein one of R¹ and R² is hydrogen and the other of R¹ and R² is *n*-propyl, and wherein R³ is hydrogen.
15. A compound as claimed in claim 13 or claim 14, wherein the compound is a di-hydrochloric acid salt.
16. A compound as claimed in any one of claims 13 to 15, comprising at least 95% of the (R)- or the (S)-enantiomer.
17. A compound as claimed in any one of claims 13 to 16 for use as a medicament.
18. A compound as claimed in claim 17, wherein the medicament is suitable for the treatment of a psychiatric or neurological disorder.
19. A compound as claimed in claim 18, wherein the psychiatric or neurological disorder is schizophrenia, Alzheimer's disease or Parkinson's disease.

20. A pharmaceutical composition, comprising a compound as claimed in any one of claims 13 to 19 and a pharmaceutically acceptable carrier or diluent.
21. A pharmaceutical composition as claimed in claim 20, suitable for the
5 treatment of a psychiatric or neurological disorder.
22. A pharmaceutical composition as claimed in claim 21, wherein the psychiatric or neurological disorder is schizophrenia, Alzheimer's disease or Parkinson's disease.
- 10 23. A method of treating a psychiatric or neurological disorder, comprising administering a therapeutically effective amount of a 2-amino-4,5,6,7-tetrahydro-6-aminobenzothiazole 5a or a salt thereof as claimed in any one of claims 13 to 19 to a subject in need of such treatment.
- 15 24. A method as claimed in claim 23, wherein the psychiatric or neurological disorder is schizophrenia, Alzheimer's disease or Parkinson's disease.

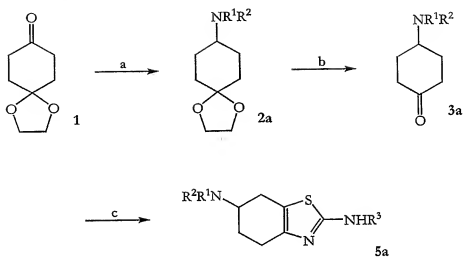


a: reductive amination with R^1R^2NH

b: deprotection

c: (i) iodine, $H_2N(C=S)NHR^3$; (ii) OH^-

Figure 1

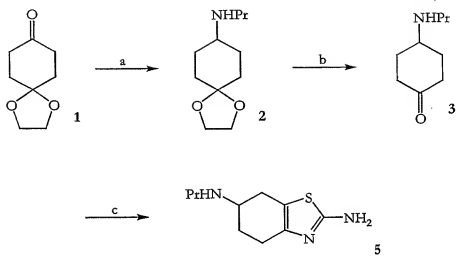


a: reductive amination with R^1R^2NH

b: deprotection

c: (i) iodine, $H_2N(C=S)NHR^3$; (ii) OH^-

Figure 2

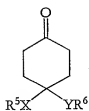


a: *n*-propylamine, NaCNBH₃, MeOH/HCl

b: aq. HCl/THF

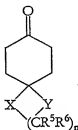
c: (i) iodine, H₂N(C=S)NH₂, ethanol, reflux; (ii) aq. NaOH

Figure 3

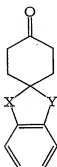


1q

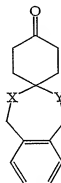
X, Y = O, S or Se

 $R^5, R^6 = \text{CO-R}^7, \text{Si(R}^7)_3$, or an optionally substituted alkyl, alkenyl, alkynyl, aryl, arylalkyl, arylalkenyl, arylalkynyl, alkylaryl, alkenylaryl or alkynylaryl group, which may include one or more heteroatoms N, O or S in its carbon skeleton
 $R^7 = \text{hydrogen or alkyl}$ and/or $\text{XR}^5, \text{YR}^6 = \text{CN}$ 

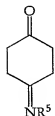
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X, Y = O, S, NR^7 or Se $n = 2 \text{ or } 3$
 $R^5, R^6 = \text{hydrogen, halide, or an optionally substituted alkyl, alkenyl, alkynyl, aryl, arylalkyl, arylalkenyl, arylalkynyl, alkylaryl, alkenylaryl or alkynylaryl group, which may include one or more heteroatoms N, O or S in its carbon skeleton}$
 $R^7 = \text{hydrogen or alkyl}$ 

1s

X, Y = O, S or NR^6 $R^6 = \text{hydrogen or alkyl}$ 

1t

X, Y = O, S or NR^6 $R^6 = \text{hydrogen or alkyl}$ 

1u

 $R^5 = \text{N(R}^6)_2 \text{ or OR}^6$
 $R^6 = \text{hydrogen, or an optionally substituted alkyl, alkenyl, alkynyl, aryl, arylalkyl, arylalkenyl, arylalkynyl, alkylaryl, alkenylaryl or alkynylaryl group, which may include one or more heteroatoms N, O or S in its carbon skeleton}$

Figure 4